POLICY STATEMENT ON THE USES OF TLVs® AND BEIs®

The Threshold Limit Values (TLVs®) and Biological Exposure Indices (BEIs®) are developed as guidelines to assist in the control of health hazards. These recommendations or guidelines are intended for use in the practice of industrial hygiene, to be interpreted and applied only by a person trained in this discipline. They are not developed for use as legal standards and ACGIH® does not advocate their use as such. However, it is recognized that in certain circumstances individuals or organizations may wish to make use of these recommendations or guidelines as a supplement to their occupational safety and health program. ACGIH® will not oppose their use in this manner, if the use of TLVs® and BEIs® in these instances will contribute to the overall improvement in worker protection. However, the user must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use.

The Introductions to the TLV®/BEI® Book and the TLV®/BEI® Documentation provide the philosophical and practical bases for the uses and limitations of the TLVs® and BEIs®. To extend those uses of the TLVs® and BEIs® to include other applications, such as use without the judgment of an industrial hygienist, application to a different population, development of new exposure recovery time models, or new exposure endpoints, stretches the reliability and even viability of the database for the TLV® or BEI® as evidenced by the individual Documentation.

It is not appropriate for individuals or organizations to impose on the TLVs® or the BEIs® their concepts of what the TLVs® or BEIs® should be or how they should be applied or to transfer regulatory standards requirements to the TLVs® or BEIs®.

Approved by the ACGIH® Board of Directors on March 1, 1988.

Special Note to User

The values listed in this book are intended for use in the practice of industrial hygiene as guidelines or recommendations to assist in the control of potential workplace health hazards and for no other use. These values are not fine lines between safe and dangerous concentrations and should not be used by anyone untrained in the discipline of industrial hygiene. It is imperative that the user of this book read the Introduction to each section and be familiar with the Documentation of the TLVs® and BEIs® before applying the recommendations contained herein. ACGIH® disclaims liability with respect to the use of the TLVs® and BEIs®.
HEAT STRESS AND STRAIN

Warning: While the TLV® is based on the ability of most healthy people to sustain a heat stress exposure, cases of heat stroke and other exertional heat illnesses do occur below the TLV®. A program of heat stress management should include acclimatization, early recognition of symptoms with appropriate first aid, and recognition of personal risk factors. Further, there is evidence of a carry-over effect from a previous day’s exposure.

This TLV® applies only to workers who are heat acclimatized. It does not apply to workers with prior heat stroke or heat exhaustion, cardiac or kidney problems, pregnancy, or obesity, the older worker, and workers on certain medications.

This TLV® has a small margin of safety. Therefore, those working near the TLV® should be warned to drink water regularly and be alert for dizziness, lightheadedness, nausea, and headache.

Goal: The goal of this TLV® is to maintain body core temperature within + 1°C of normal (37°C) for the average person. For most individuals, body core temperature will be below 38.3°C. Body core temperature can exceed 38.3°C under certain circumstances with selected populations, environmental and physiologic monitoring, and other controls.

More than any other physical agent, the potential health hazards from work in hot environments depend strongly on physiological factors that lead to a range of susceptibilities depending on the level of acclimatization. Therefore, professional judgment is of particular importance in assessing the level of heat stress and physiological heat strain to adequately provide guidance for protecting nearly all healthy workers with due consideration of individual and the type of work. Assessment of both heat stress and heat strain can be used for evaluating the risk to worker safety and health. A decision-making process is suggested in Figure 1. The exposure guidance provided in Figures 1 and 2 and in the associated documentation of the TLV® represents conditions under which it is believed that nearly all heat acclimatized, adequately hydrated, unmedicated, healthy workers may be repeatedly exposed without adverse health effects. The Action Limit (AL) is similarly protective of unacclimatized workers and represents conditions for which a heat stress management program should be considered. While not part of the TLV®, elements of a heat stress management program are offered. The exposure guidance is not a fine line between safe and dangerous levels.

Heat Stress is the net heat load to which a worker may be exposed from the combined contributions of metabolic heat, environmental factors (e.g., air temperature, humidity, air movement, and radiant heat), and clothing requirements. A mild or moderate heat stress may cause discomfort and may adversely affect performance and safety, but it is not harmful to health. As the heat stress approaches human tolerance limits, the risk of heat-related disorders increases.

Heat Strain is the overall physiological response resulting from heat stress. The physiological responses are dedicated to dissipating excess heat from the body.

FIGURE 1. Evaluating heat stress and strain.

Acclimatization is a gradual physiological adaptation that improves an individual’s ability to tolerate heat stress. Acclimatization requires physical activity under heat-stress conditions similar to those anticipated for the work. With a recent history of heat-stress exposures of at least two continuous hours (e.g., 5 of the last 7 days to 10 of 14 days), a worker can be considered acclimatized for the purposes of the TLV®. Its loss begins when the activity under those heat stress conditions is discontinued, and a noticeable loss occurs after four days and may be completely lost in three to four weeks. Because acclimatization is to the level of the heat stress exposure, a person will not be fully acclimatized to a sudden higher level, such as during a heat wave.
The decision process illustrated in Figure 1 should be started if (1) a qualitative exposure assessment indicates the possibility of heat stress, (2) there are reports of discomfort due to heat stress, or (3) professional judgment indicates heat stress conditions.

Section 1: Clothing. Ideally, free movement of cool, dry air over the skin's surface maximizes heat removal by both evaporation and convection. Evaporation of sweat from the skin is the predominant heat removal mechanism. Water-vapor-impermeable, air-impermeable, and thermally insulating clothing, as well as encapsulating suits and multiple layers of clothing, severely restrict heat removal. With heat removal hampered by clothing, metabolic heat may produce excessive heat strain even when ambient conditions are considered cool.

Figure 1 requires a decision about clothing and how it might affect heat loss. The WBGT-based heat exposure assessment was developed for a traditional work uniform of a long-sleeve shirt and pants. If the required clothing is adequately described by one of the ensembles in Table 1 or by other available data, then the "YES" branch is selected.

If workers are required to wear clothing not represented by an ensemble in Table 1, then the "NO" branch should be taken. This decision is especially applicable for clothing ensembles that are 1) totally encapsulating suits or 2) multiple layers with no data available for adjustments. For these kinds of ensembles, Table 2 is not a useful screening method to determine a threshold for heat-stress management actions and some risk must be assumed. Unless a detailed analysis method appropriate to the clothing requirements is available, physiological and signs/symptoms monitoring described in Section 4 and Table 4 should be followed to assess the exposure.

### Table 1. Clothing-Adjustment Factors for Some Clothing Ensembles

<table>
<thead>
<tr>
<th>Clothing Type</th>
<th>Addition to WBGT [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work clothes (long-sleeve shirt and pants)</td>
<td>0</td>
</tr>
<tr>
<td>Cloth (woven material) coveralls</td>
<td>0</td>
</tr>
<tr>
<td>Double-layer woven clothing</td>
<td>3</td>
</tr>
<tr>
<td>SMS polypropylene coveralls</td>
<td>0.5</td>
</tr>
<tr>
<td>Polyolefin coveralls</td>
<td>1</td>
</tr>
<tr>
<td>Limited-use vapor-barrier coveralls</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*These values must not be used for completely encapsulating suits, often called Level A. Clothing Adjustment Factors cannot be added for multiple layers. The coveralls assume that only modesty clothing is worn underneath, not a second layer of clothing.

Section 2: Screening Threshold Based on Wet-Bulb Globe Temperature (WBGT). The WBGT offers a useful first order index of the environmental contribution to heat stress. It is influenced by air temperature, radiant heat, air movement, and humidity. As an approximation, it does not fully account for all the interactions between a person and their environment and cannot account for special conditions such as heating from a radiofrequency/microwave source.

WBGT values are calculated using one of the following equations:

- With direct exposure to sunlight:
  \[ WBGT_{out} = 0.7 \cdot T_{mwb} + 0.2 \cdot T_g + 0.1 \cdot T_{db} \]

- Without direct exposure to the sun:
  \[ WBGT_{in} = 0.7 \cdot T_{mwb} + 0.3 \cdot T_g \]

where:
- \( T_{mwb} \) = natural wet-bulb temperature (sometimes called NWB)
- \( T_g \) = globe temperature (sometimes called GT)
- \( T_{db} \) = dry-bulb (air) temperature (sometimes called DB)

Because WBGT is only an index of the environment, the screening criteria are adjusted for the contributions of work demands and clothing. Table 2 provides WBGT criteria suitable for screening purposes. For clothing ensembles listed in Table 1, Table 2 can be used when the clothing adjustment values are added to the environmental WBGT.

To determine the degree of heat stress exposure, the work pattern and demands must be considered. If the work (and rest) is distributed over more than one location, then a time-weighted average WBGT should be used for comparison to Table 2 limits.
<table>
<thead>
<tr>
<th>Recovery Allocation of Work in a Cycle of Work and</th>
<th>TLV® (WBGT values in °C)</th>
<th>Action Limit (WBGT values in °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 to 100%</td>
<td>Light: 31.0</td>
<td>Light: 28.0</td>
</tr>
<tr>
<td></td>
<td>Moderate: 28.0</td>
<td>Moderate: 25.0</td>
</tr>
<tr>
<td></td>
<td>Heavy: –</td>
<td>Heavy: –</td>
</tr>
<tr>
<td>50 to 75%</td>
<td>Light: 31.5</td>
<td>Light: 28.5</td>
</tr>
<tr>
<td></td>
<td>Moderate: 29.0</td>
<td>Moderate: 26.0</td>
</tr>
<tr>
<td></td>
<td>Heavy: 27.5</td>
<td>Heavy: 24.0</td>
</tr>
<tr>
<td>25 to 50%</td>
<td>Light: 32.0</td>
<td>Light: 29.5</td>
</tr>
<tr>
<td></td>
<td>Moderate: 30.0</td>
<td>Moderate: 27.0</td>
</tr>
<tr>
<td>0 to 25%</td>
<td>Light: 32.5</td>
<td>Light: 29.0</td>
</tr>
<tr>
<td></td>
<td>Moderate: 30.5</td>
<td>Moderate: 27.0</td>
</tr>
<tr>
<td></td>
<td>Heavy: –</td>
<td>Heavy: –</td>
</tr>
</tbody>
</table>

**Notes:**
- See Table 1 and the Documentation for work demand categories.
- WBGT values are expressed to the nearest 0.5°C.
- The thresholds are compared to a TWA-Metabolic Rate where the metabolic rate for rest is taken as 115 W and work is the representative (mid-range) value of Table 3. The time base is taken as the proportion of work at the upper limit of the percent work range (e.g., 30% for the range of 25 to 50%).
- If work and rest environments are different, hourly time-weighted averages (TWA) WBGT should be calculated and used. TWAs for work rates should also be used when the work demands vary within the hour, but note that the metabolic rate for rest is already factored into the screening limit.
- Values in the table are applied by reference to the “Work-Rest Regimen” section of the Documentation and assume 8-hour workdays in a 5-day workweek with conventional breaks as discussed in the Documentation. When workdays are extended, consult the “Application of the TLV®” section of the Documentation.
- Because of the physiological strain associated with Heavy and Very Heavy work among less fit workers regardless of WBGT, criteria values are not provided for continuous work and for up to 25% rest in an hour for Very Heavy. The screening criteria are not recommended, and a detailed analysis and/or physiological monitoring should be used.
- Table 2 is intended as an initial screening tool to evaluate whether a heat stress situation may exist (according to Figure 1) and thus, the table is more protective than the TLV® or Action Limit (Figure 2). Because the values are more protective, they are not intended to prescribe work and recovery periods.
TABLE 4. Guidelines for Limiting Heat Strain

Monitoring heat strain and signs and symptoms of heat-related disorders is sound industrial hygiene practice, especially when clothing may significantly reduce heat loss. For surveillance purposes, a pattern of workers exceeding the heat strain limits is indicative of a need to control the exposures. On an individual basis, the limits represent a time to cease an exposure and allow for recovery.

One or more of the following measures may mark excessive heat strain, and an individual's exposure to heat stress should be discontinued when any of the following occur:

- Sustained (several minutes) heart rate is in excess of 180 bpm (beats per minute) minus the individual’s age in years (e.g., 180 – age) for individuals with assessed normal cardiac performance; or
- Body core temperature is greater than 38.5°C (101.3°F) for medically selected and acclimatized personnel; or
- Greater than 38°C (100.4°F) in unselected, unacclimatized workers; or
- Recovery heart rate at one minute after a peak work effort is greater than 120 bpm; or
- There are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness.

An individual may be at greater risk of heat-related disorders if:

- Profuse sweating is sustained over hours; or
- Weight loss over a shift is greater than 1.5% of body weight; or
- 24-hour urinary sodium excretion is less than 50 millimoles

EMERGENCY RESPONSE: If a worker appears to be disoriented or confused, suffers inexpressible irritability, malaise, or chills, the worker should be removed for rest in a cool location with rapidly circulating air and kept under skilled observation. Absent medical advice to the contrary, treat this as an emergency with immediate transport to a hospital. An emergency response plan is necessary.

— NEVER ignore anyone’s signs or symptoms of heat-related disorders —
After implementation of the job-specific controls, it is necessary to assess their effectiveness and to adjust them as needed.

TABLE 5. Elements to Consider in Establishing a Heat Stress Management Program

<table>
<thead>
<tr>
<th>Element to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor heat stress (e.g., WGBT Screening Criteria in Table 2) and heat strain (Table 4) to confirm adequate control</td>
</tr>
</tbody>
</table>

**General Controls**
- Provide accurate verbal and written instructions, annual training programs, and other information about heat stress and strain
- Encourage drinking small volumes (approximately 1 cup) of cool, palatable water (or other acceptable fluid replacement drink) about every 20 minutes
- Encourage employees to report symptoms of heat-related disorders to a supervisor
- Encourage self-limitation of exposures when a supervisor is not present
- Encourage co-worker observation to detect signs and symptoms of heat strain in others
- Counsel and monitor those who take medications that may compromise normal cardiovascular, blood pressure, body temperature regulation, renal, or sweat gland functions; and those who abuse or are recovering from the abuse of alcohol or other intoxicants
- Encourage healthy lifestyles, ideal body weight and electrolyte balance
- Adjust expectations of those returning to work after absence from hot exposure situations and encourage consumption of salty foods (with approval of physician if on a salt-restricted diet)
- Consider pre-placement medical screening to identify those susceptible to systemic heat injury
- Monitor the heat stress conditions and reports of heat-related disorders

**Job-Specific Controls**
- Consider engineering controls that reduce the metabolic rate, provide general air movement, reduce process heat and water vapor release, and shield radiant heat sources, among others
- Consider administrative controls that set acceptable exposure times, allow sufficient recovery, and limit physiological strain
- Consider personal protection that is demonstrated effective for the specific work practices and conditions at the location

— NEVER ignore anyone's signs or symptoms of heat-related disorders —

References